COMPARISON BETWEEN SIEVE ANALYSIS & HYDROMETER WITH LASER PARTICLE ANALYZER TO DETERMINE PARTICLE SIZE DISTRIBUTION

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ABSTRAK

Penentuan agihan saiz zarah tanah menggunakan kaedah ayakan, hidrometer juga menggunakan laser menghadapi masalah yang dialami secara semulajadi, terutamanya disebabkan oleh masalah dalam menentukan saiz zarah yang tidak sama bentuknya. Oleh yang demikian, kaedah-kaedah ini hanya digunakan untuk menentukan agihan saiz zarah sahaja. Objektif kajian ini adalah untuk menentukan agihan saiz zarah tanah juga ingin mengenalpasti hubungkait antara kaedah laser dengan kaedah ayakan dan hidrometer. Sampel tanah diambil dari tiga kawasan berbeza sekitar Kuantan – Gambang. Untuk Kaedah Laser, mesin CILAS diguna pakai dan untuk pengiraannya pula, Teori Mie telah diguna pakai. Nilai bagi 1.5 dan 0.2 yang digunakan untuk bahagian sebenar dan terma imaginasi memberikan keputusan yang memuaskan untuk kiraan model optikal. Peratus isipadu untuk tanah liat bagi kaedah laser adalah lebih kecil berbanding dengan kaedah ayakan dan hidrometer. Tren berlawanan pula didapati di bahagian pecahan tanah lumpur atau kelodak. Pemalar yang digunakan dalam kaedah-kaedah menentukan jenis tanah samaada tanah liat, tanah liat lembut, lumpur atau pasir adalah 0.702, 0.689, dan 0.821 berturut-turut. Hubung kait yang baik dapat dilihat antara ukuran dan kiraan yang dilakukan dalam kaedah laser manakala hubungkait yang kurang baik didapati daripada kaedah ayakan dan hydrometer. Kaedah laser memberikan lengkung agihan saiz partikel yang sentiasa bersambung yang memudahkan proses pembahagian jenis-jenis dan klasifikasi tanah mengikut kelas masing-masing.

ABSTRACT

Determination of soil particle size distribution (PSD) by sieving, hydrometer as well as by laser particle analyzer suffers from inherent flaws, mainly due to the difficulty in defining the size of irregularly shaped particles. Therefore these methods yield only estimates of particle size distribution. The objective of this study was to determine a functional relationship exists between the PSDs obtained by the combined sieve-hydrometer method and those obtained by laser particle analyzer. Samples from 3 different places in Kuantan were analyzed. For the laser particle analyzer CILAS Particle analyzer were used employing the Mie theory. Values of 1.5 and 0.2 for the real part and the imaginary term of the reflective index, respectively, gave satisfactory results for the optical model calculations. Volume percentage of the clay-size fraction obtained by laser particle analyzer was generally lower than mass percentage of the clay fraction derived by the combined sieve & hydrometer method. The opposite trend was noted for the silt-size fraction. Coefficient of determination for the regression equations for the clay, silt, and sand fractions determined by the two methods were 0.702, 0.689, and 0.821, respectively. Good agreement between measured and calculated laser particle analyzer values for one size class was accompanied by poor agreement between measured and calculated values for the other. The laser particle analyzer method provides a continuous particle size distribution curve, which enables a detailed data analysis and a flexible application of different particle size distribution dependent classification system.

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LIST OF SYMBOLS

BS	-	British Standard
BSCS	-	British Soil Classification System
C_m	-	Meniscus correction
D	-	Particle diameter
G_S	-	Specific gravity
H_R	-	Effective depth
JKR	-	Jabatan Kerja Raya
K	-	Percent finer (%)
L_O	-	Initial length
L_D	-	Oven-dried length
LL	-	Liquid limit
LS	-	Linear shrinkage
M_t	-	Temperature correction
m	-	Mass
PI	-	Plasticity index
PL	-	Plastic limit
R	-	Fully corrected reading
R_h	-	True reading
R_h'	-	Hydrometer reading
SL	-	Shrinkage limit
η	-	Viscosity of water
x	-	Dispersant correction

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CHAPTER 1

INTRODUCTION

1.1 Background of project

Soils are a vital resource in every country of the world. An understanding of the soil properties begins at the simple level of what can be observed for example the particle size distribution. Particle size distribution is a list of values or a mathematical function that defines the relative amounts of particles present, sorted according to size. Particle Size Distribution is also known as grain size distribution (Frieden, B. J., & Sagalyn, L. B. (1989).

The method used to determine Particle Size Distribution is called particle size analysis and the apparatus in conversional method will be sieve analysis and hydrometer test while more advanced, fasters, reliable and accuracy method is laser particle size analyzer.

The result obtained from this laboratory assessment then will be used to classify the soil. Generally soil can be divided into three major groups which are coarse, fine and organic soil. The British Soil Classification System (BSCS) will be use to classify the soil sample.

Soil consists of individual particles, or grains. Particles are three-dimensional objects for which three parameters (the length, breadth and height) are required in order to provide a complete description. Most sizing techniques therefore assume that the material being measured is spherical, as a sphere is the only shape that can be described by a single number (its diameter).

1.2 Problem Statement

Particle size distribution is one of the most fundamental physical properties of a soil, defining, for example the soil texture, and strongly affecting many physical and chemical soil properties. It is typically presented as percentage of the total mass of soil occupied by a given size fraction.

In soil mechanic and geotechnical engineering it is really important to know the particle size distribution in order to know the soil condition content in percentage of clay, silt or sandy sand. Problem in soil mechanics had begun to be identified and addressed analytically by the beginning of the eighteenth century (Heyman, 1972). Limitations of traditional methods for particle-size analysis warrant the investigation of new techniques.

This study will compare finding from particle size distribution of soil sample by using sieve analysis & hydrometer and laser particle analyzer. This study also will identify suitable method to determine the particle size distribution. This study will explore two types of test which are sieve analysis & hydrometer test and laser particle analyzer.

1.3 Objectives

To achieve this study, several of objectives has stated:-

1. To determine the particle size distribution of soils by using two different methods which is sieve analysis & hydrometer test and laser particle analyzers;

2. Comparison the result from sieve analysis & hydrometer with laser particle analyzer to give the suite of suitability for particle size distribution analysis; and

3. To determine the soil type in accordance to British Soil Classification System (BSCS).

1.4 Scope of study

In this academic study, scopes of the studies are:

a) The location site are several places in Kuantan,Pahang.

b) Sample are collected from several places in Kuantan,Pahang for the testing which label sample 1, sample 2, and sample 3.

c) Conduct two testing on the same type of soil which are sieve analysis & hydrometer test and laser particle diffraction analyzer to determine the particle size distribution.

d) Differentiate those two tests by using graph of percentage of the particle size distribution to know which test gives more suitability.

1.5 Significance of study

It is necessary to know the particle size distribution of soils to determine whether they are suitable for particular applications that we need to use either in concrete mixing, designing soil or geotechnical structure. Sieve analysis & hydrometer testing and also laser particle size analyzer are very important in order to know which test are more suitable and also it will make the contractor to know the soil properties as well as the soil conditions.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the review of soil and the soil classification system that will be use to classify the soil sample after running the laboratory testing will be presented. More than that, the testing that use to determine the particle size distribution also will be presented.

Particle size distribution in soil is one of the more interesting soil physical properties. The information provided by Particle Size Distribution are often used to infer soil functioning and use. The traditional method of characterizing particle sizes in soils is to divide the array of possible particle sizes into three arbitrary separable size ranges: sand, silt and clay (Lin-Sien Lum, 2001).

An alternative to this approach is to measure and display the complete distribution of particle sizes. Sieves can be used to separate and determine the content of the relatively large particles of sand and coarse silt.

However the common source of Particle Size Distribution data is the process of sedimentation of particles in water and the most popular techniques are the hydrometer method, this method is based on the Stoke's law and employs the relationship among time, travel distance, and the diameter of a sphere subject to sedimentation in a viscous liquid (Sivakugan N,,2000)

According to Bouyoucos (1925), for many years, sedimentation methods have been used for measuring soil particle- size distributions. In the hydrometer method, first described by Bouyoucos (1925), the floatation depth of a hydrometer is measured as a function of time, providing an indication of the solution density.

The sieve analysis is a determination of the proportions of particles lying within certain size ranges in a granular material by separation on sieves of different size openings. Sieve analysis is also known as screen analysis. Combined sieve-and hydrometer method is one of the two conventional methods commonly used in research and practice in all branches of science and engineering dealing with soils while laser diffraction is a modern method.

Laser diffraction is measurements one obtains information about particle size distribution through measurements of scattering intensity as a function of the scattering angle and the wavelength and polarization of light based on applicable scattering models.

The instrument measures particle size over the range of 0.045 to 2000 µm. The laser beam accurately measures particles of an apparent cross-sectional diameter greater than 0.4 µm (Buurman et al., 1997). The calculation module offers the use of two optical modes, the Fraunhoffer diffraction model and the Mie theory. It should be borne in mind that the Mie theory applies rigorously to spherical, homogeneous particles and fits less satisfactorily nonspherical or nonhomogeneous particles (Jonasz, 1991). In this study, several tests will be conducted to compare between these three tests.

2.2 Definition of soil

Soil is the term given to the unbounded, granular material which covers much of the surface of the Earth that is not under water (William Powrie, 1997). Soil consists primarily of solid particles, which range in size from less than a micron to several millimeters. Soil is used as a construction material in various civil engineering projects, and it supports structural foundations (Braja M.Das, 2002).

Much of the work of foundation and geotechnical engineers involves soil. It is imperative therefore to know the definition of the soil. A simple definition of soil is that it is a particulate medium, with particles resulting from a variety of geologic processes, and is composed of a variety of minerals, with particle size ranging from the order of magnitude of 1 μ to 1 m (Rodrigo Salgado, 2008). The space between soil particles, referred to as the pore space, is filled with one or more of the following: air, some other gas, water, or some other liquid.

Beyond the amazing range of soil particle sizes, soil is complex in other ways. Soil particles may be arranged in densely packed states or very loose ones. Soils at depth exist under large stresses; soils close to the surface exists under small stresses. Particle arrangements can vary not only in terms of how dense they are but also in the way particles are in contact with each other (Rodrigo Salgado, 2008). The pore fluid chemistry can vary. In some soils, particles interact physicochemical with the pore fluid; any changes in pore fluid chemistry can affect soil behavior.

2.2.1 Soil description

Soil description deals with the systematic categorization of soils based on distinguishing characteristics as well as criteria that dictate choices in use. Four information fields are provided for recording and determining the soil description which are; terrain texture, surficial material, surface expression and geomorphological process, respectively (Howes and Kenk, 1997).

2.3 Physical properties of soil

Soil engineers usually classify soils to determine whether they are suitable for particular applications (Sam Helwany, 2007). For instance, borrowing soil from other sites, the properties that need to be considered:

i. The particle size distribution
ii. The consistency of each soil
iii. The classification of the soil

Soils are porous and open bodies, yet they retain water. They contain mineral particles of many shapes and sizes and organic material which is colloidal (particles so small they remain suspended in water) in character. The solid particles lie in contact one with the other, but they are seldom packed as closely together as possible.

The size distribution of primary mineral particles, called soil texture, has a strong influence on the properties of a soil. Particles larger than 2 mm in diameter are considered inert. Little attention is paid to them unless they are boulders that interfere with manipulation of the surface soil. Particles smaller than 2 mm in diameter are divided into three broad categories based on size. Particles of 2 to 0.05 mm diameter are called sand; those of 0.05 to 0.002 mm diameter are silt; and the <0.002 mm particles are clay.

The texture of soils is usually expressed in terms of the percentages of sand, silt, and clay. To avoid quoting exact percentages, 12 textural classes have been defined. Each class, named to identify the size separate or separates having the dominant impact on properties, includes a range in size distribution that is consistent with a rather narrow range in soil behavior. The loam textural class contains soils whose properties are controlled equally by clay, silt and sand separates. Such soils tend to exhibit good balance between large and small pores; thus, movement of water, air and roots is easy and water retention is adequate. Soil texture, a stable and an easily determined soil characteristic, can be estimated by feeling and manipulating a moist sample, or it can be determined accurately by laboratory analysis. Soil horizons are sometimes separated on the basis of differences in texture.

2.3.1 Particle Size Distribution

Civil engineers describe and classify soils according to the particle size, rather than according to their age, origin or mineralogy (William Powrie, 1997). Different particle sizing techniques may produce different results depending upon the properties of the particles being measured.

Methods such as sedimentation and cascade impaction are based on the surface area of the particles and will vary with roughness and shape. Sieving measures the smaller dimensions of a sample, therefore rod-shaped particles will be difficult to measure accurately. Suitable particle sizing must consider the volume of the particle being measured.

There are several methods to determine Particle Size Distribution which is called sieve analysis, hydrometer and laser particle analyzer. Furthermore, Particle size distribution is used for the prediction of soil hydraulic properties (Bloeman, 1980; Arya and Paris, 1981).

The standard analysis of particle size distribution involves the dispersion of mineral particles after destroying the organic matter (D.L Rowell, 1994). The size classes are the separated using sieves and by sedimentation and the mass in each particles class is determined. The method also serves separates the different size fraction for observation and analysis. The effects of sedimentation on the separation of soil particles in a field situation can be seen where soil has been puddle by cattle or machinery during a wet period around a drinking trough or in a gateway. After this disturbance the sand settles quickly followed by silt and the clay to form a layered skin when the soil subsequently dries out (Reith J.W.S, 1962).

2.3.2 Soil consistency

A system called Atterberg Limits is used to describe the Liquid Limits (LL), Plastics Limit (PL), and Shrinkage Limit (SL) of a soil. According to this system as water is added to a dry soil, the soil changes from solid to semi-solid to plastic to liquid. (Das, B.M., 2002)

The moisture content in the soil at the threshold between semi-solid and plastic is called the plastic limit. The moisture content in the soil at the threshold between plastic and liquid is called the liquid limit. Liquid limit is determined by forming a groove in a dish of soil and impacting the dish until the groove closes. The test is done following the ASTM procedure D-4318. The plastic limit is determined by rolling a thread of soil on a glass plate until the 1/8-inch-diameter thread begins to crumble. This technique is also explained in ASTM procedure D-4318. A large liquid limit indicates high compressibility and high shrinks swell tendencies. Subtracting the plastic limit from the liquid limit yields the plasticity index. A large plasticity index indicates low shear strength. (Das, B.M., 2002)

2.3.3 Soil classification

Soil classification deals with the systematic categorization of soils based on distinguishing characteristics as well as criteria that dictate choices in use (Braja.M.Das). Soil is classified into different groups or categories so that relationships are better understood between different soils. The different groupings help determine the usefulness of any soil for any particular use. Soil classification is the separation of soil into classes or groups each having similar characteristics and potentially similar behavior. A classification for engineering purposes should be based mainly on mechanical properties, for example; permeability, stiffness, strength. The class to which a soil belongs can be used in its description.

One of the first classification systems was developed by the Russian scientist Dokuchaev around 1880, it was modified a number of times by American and European researches and developed into the system commonly used until the 1960's.

It was based on the idea that soils have a particular morphology based on the materials and factors that form them. In the 1960's a different classification system began to emerge that stressed just soil morphology and relied less on soil parental materials and soil forming factors. Since then it has undergone further modifications.

The two most widely used classification systems are the American Association of State Highway and Transportation Officials (AASHTO) and the Unified Soil Classification System (USCS).